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ABSTRACT

The purpose of this study was to determine: (1) how different types of dynamic visual facilitate the achievement of specific types of educational objectives; (2) whether the use of dynamic visualization influenced the amount of time needed by learners to process the information; and (3) whether there is an interaction between the amount of time learners view the animation and the different levels of dynamic visualization. Two hundred students were randomly assigned to four treatments, received their respective instructional presentation and received four individual criterion measures. Results indicated that insignificant differences in achievement existed among the visual treatment groups on all criterion measures and that an insignificant interaction was found to exist between time and dynamic visualization. (Contains 11 references and 5 tables.) (Author/AEF)

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Effect of Time and Level of Visual Enhancement in Facilitating Student Achievement of Different Educational Objectives

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Abstract

The purpose of this study was to determine: a. how different types of dynamic visual facilitate the achievement of specific types of educational objectives, b. whether the use of dynamic visualization influenced the amount of time needed by learners to process the information, and c. whether there is an interaction between the amount of time learners view the animation and the different levels of dynamic visualization. Two hundred students were randomly assigned to four treatments, received their respective instructional presentation and received four individual criterion measures. Results indicated that insignificant differences in achievement existed among the visual treatment groups on all criterion measures and that an insignificant interaction was found to exist between time and dynamic visualization.

Introduction

Visualization properly designed, and positioned in instructional presentations has been found to be an important variable in facilitating student achievement of different types of educational objectives (Dwyer, 1978). However, the use of visualization alone, while it can significantly improve achievement, does not always optimize achievement of the more complex types of learning outcomes (Dwyer, 1987). Static visuals in and of themselves are limited in their ability to instigate the higher levels of information processing since at best they represent suggested motion attributes in dramatic form (Reiber & Kini, 1996). Park and Hopkins (1993) have suggested that dynamic visual displays which utilize graphic movement in visualization to identify, interpret and reduce the level of abstraction will facilitate higher levels of information processing and lead to higher levels of achievement. It is assumed that the static visuals and narration along with increased animation would provide additive codes leading to more effective encoding and knowledge transfer of the information being presented. It was also anticipated that the use of animation (changing color, motion, etc.) in static visuals would focus learning attention more precisely, facilitate focused interaction and thereby result in improved learning outcomes. Additionally, an increased interaction with the content materials would necessitate an increased amount of time required for learners to interact and process the information being presented. Carroll (1963) reports that the amount of time required would be proportional to the complexity of the visualization, the types of animation and the level of learning to be achieved. Specifically, the purpose of this study was to: a. determine how different types of dynamic visuals facilitate the achievement of specific types of educational objectives, b. determine whether the use of dynamic visualization influences the amount of time needed by learners to process the information and c. determine whether there is an interaction between amount of time learners view the animation and the different levels of dynamic visualization.

Methodology

The 2000 word instructional unit used in study was intended to instruct learners on the nomenclature of the heart, and the functions of the various parts of the heart during its systolic and diastolic phases. The lesson included 19 separate "instructional frames" comprised of sound and graphics elements. Each "frame" was accompanied by some audio narration that described and supported the visual being shown. In this case, it identified and described the parts of the heart and their functions. The lesson allowed the learner only one pathway (a linear progression) through the lesson, so that the 19 instructional frames comprising the lesson were presented to all students in a fixed sequence. Within each instructional frame there was a fixed sequence of audio and visual components. Macromedia Director was chosen for development and delivery since there was a need for the simultaneous presentations of audio narration and dynamic visual elements. For each of the 19 frames, the appearance of the graphic was followed by five seconds of silence, then by the appropriate narration. Following the narration the

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student was given an opportunity for silent reflection. Depending on the timing treatment, this post-narration time was either 8 seconds (T_1) or self-paced, (T_2). A stop-watch script was written into the instructional program, which recorded each student's reflection time. The watch began automatically at the end of the narration for each frame. Simultaneously, a button appeared in the frame entitled "Continue," which the student could mouse-click at any time to move on to the next frame of instruction.

Prior to the instructional unit, the participants were given a brief orientation to the study, which explained its purpose, and informed them about the use of the silent time during each frame. It was explained that: 1) the silent time preceding the narration was designed to familiarize them with, and orient them to the new features presented in the new visual, 2) the audio narration, to communicate the instructional message, or content for the frame, and 3) the silent time following the narration, to allow a time for reflection and rehearsal. The participants also were asked to follow this strategy carefully and consistently throughout the learning module. The orientation also informed the student about the testing procedure as well as the approximate time it would take to complete the experiment. They were asked to place their complete focus on the learning at hand and to participate as fully as possible in all aspects of the learning and testing experience.

Instructional Time ("T" Variable)

The instructional time variable examined how enhancements such as dynamic visualization in instruction, affected the length of time students' needed to "attend to" (study) the additional visual cues, or details. Each of the dynamic visual strategies added visual information that the learner was required to process. For the purposes of this study, pre-narration time and narration time remained constant across the treatments. Pre-narration time – when a new visual appeared, five seconds of silence was given for students to orient themselves to the components of the new visual before the narration began. Since all subjects were given this period of orientation prior to the narration, it was considered a constant. Narration time – although the timing for the narration varied from scene to scene, depending on the complexity of each explanation, it was identical from treatment to treatment. In other words, each student receiving instruction spent an equal time listening to the narrative. Therefore, narration time was considered a constant. Post-narration time – for the purposes of this study, only the period of time that followed the narration was manipulated. The students were directed to use this time to scan the visual and to reflect upon the information presented by the narration. Students were randomly assigned to one of two timing treatments.

1. T_1 – Timing Treatment #1 – 8 seconds:
   Post-narration time equaled 8 seconds for all frames. Once the 8 seconds elapsed, the instructional program automatically advanced to the next frame of instruction.
2. T_2 – Timing Treatment #2 – self paced:
   Post-narration time was controlled by the learner. When the narration for the frame was finished a "continue" button appeared on the screen. At this point, the student could study the current visual for as long as needed, and click on the button to proceed to the next frame. For this self-paced treatment, study times were recorded for each learner for each frame.

Treatments - Visual Enhancements ("V" Variable)

1. V_1 – Still Graphics (Control): The Control Group treatment contained 19 static visuals frames consisting of colored line drawings of the human heart. These simple illustrations contained character-generated words on the screen in combination with arrows and labels that identified the elements being presented in the narration.

2. V_2 – Progressive Reveal: Progressive Reveal was a dynamic visual enhancement that entailed a sudden color change in, or a sudden addition of graphic elements. Location of the animation enhancements in each treatment was based on item analysis conducted by Torres (1990). A sudden color change was intended to draw the learner's attention (cueing) to that part of the graphic being discussed in the narration. In the heart presentation, whenever an element of the graphic is mentioned, or described, the viewer's eye is drawn to that element by a sudden change in color in the element. The sudden additional of an arrow during narration represented either the direction of some movement (blood flow), or of some hidden pressure that occurred in the heart. The Progressive Reveal is intended to help the learner locate the important elements within the whole, and to ignore the extraneous detail. Progressive Reveal was intended to improve student's abilities on identification, terminology and comprehension test items that require students to recall names of parts or functions.

3. V_3 – Animation: Animation was a dynamic visual enhancement that generated graphic motion simulating the mechanics of the real world, such as the flow of blood, or motions of the valves, muscles, and other moving elements of the heart. This dynamic visual display added the element of motion, which was intended to graphically demonstrate the movement of parts or the flow of blood through the heart, as it was being described in the audio narrative. Animation was intended to promote learning at the conceptual and rule level. The animation treatment would most benefit students on terminology and comprehension questions that recalled information related to motions, operations, processes, functions and how they were interrelated.
4. V_4 – Animation and Progressive Reveal: This treatment combined the elements of Progressive Reveal and Animation described above. This combination of dynamic visual elements attempted to focus students' attention on relevant details and on the movements, operations, processes, and functions inherent in the elements being described by the audio narrative. When used, this combination of methods was intended to give the student a more comprehensive understanding of the interrelationships between the parts and functions of the heart.

Each enhancement described above was assigned to a frame on the basis of its value for supporting certain instructional objectives articulated in the narration for that frame. In other words, the Progressive Reveal treatment only was used when the narration identified, described, or named parts or functions of the heart, while the Animation treatment only was used when the narration described some movement, flow, or process.

Table 1. Summary of Visual Enhancement Strategies

Treatment V_1 (control)	Narration, Color Heart Drawings, Labels
Treatment V_2	Treatment, Color Heart Drawings, Labels, and Progressive Reveal
Treatment V_3	Narration, Color Heart Drawing, Labels, and Animation
Treatment V_4	Narration, Color Heart Drawings, Labels, Animation and Progressive Reveal

During the presentation of one of the three visually enhanced treatments, the selection and use of that particular visual enhancement strategy was synchronized with the audio narration during any instructional frame, or any portion of a frame, according to the following criteria:

Throughout Control Treatment V_1, still graphic images were employed throughout the presentation. A total of 19 images were employed. For Frame #18, which described the Systolic Phase (in which the heart exhibits two distinct movements), two still images were presented consecutively. In treatments V_2 and V_4, the still graphics were enhanced by the addition of Progressive Reveal. Whenever parts of the heart were being introduced, described, or identified, the parts and their labels would suddenly change color to attract the learner's attention to those elements. In Treatment V_2 and V_4, arrows appeared as needed to show the direction of some movement or force. During Treatments V_3 and V_4, animation was used only during those frames, or potions of frames that describe motion, including the contraction of the heart, the movement of internal parts of the heart, or the flow of blood from chamber to chamber. During Treatment V_4, both still and animated frames were enhanced by the addition of Progressive Reveal as needed when the narrative introduced, described or identified parts or areas of the heart. As in Treatment V_2, this enhancement involved a sudden color change for the part and for its corresponding label.

Criterion Measures

The dependent variables used in this study were the achievement levels of students on specific learning objectives. Achievement of the specific learning objectives was determined by the following criterion measures (Dwyer, 1978, 45-47)

Drawing Test (20 items): This test consisted of a numbered list of twenty items (naming the parts of the heart) depicted in the instructional unit. The students were asked to draw a reasonable facsimile of the human heart, and to place the number corresponding to each item in its correct location on the drawing. Emphasis was placed on the accurate positioning of the numbered items, not on the quality of the drawing. The drawing test was intended to

assess the students' ability to reproduce or reconstruct the heart and to maintain the appropriate special and contextual relationship between and among the various parts.

Terminology Test (20 items): Given five choices in each item in a multiple choice test, learners were required to select the part or function of the heart described in each item. This test was designed to measure a student's ability to choose the appropriate graphic representation of a part or function, given an abstract definition or description. This related to knowledge of facts, terms, and definitions, which would be needed as prerequisites for the learning of concepts, rules, and principles, the higher intellectual skills, which would entail more complex levels of learning abstraction.

Comprehension test (20 items): Each question described the activity in a certain part of the heart, at a single moment in the cycle of the heart's movements. It required students to show how another part (or parts) would appear at that same moment by selecting an illustration which most accurately represented that condition. This test required students to have a thorough understanding of the heart, its parts, its sequence of movements and cycles, its simultaneous processes, and the relationships between and among the parts of the heart at critical moments during its cycle of activity. This test was intended to measure a students' ability to apply the facts, concepts, rules, and processes presented in the instruction.

In the case of the Drawing Test, Dwyer's original version (1965) was used. The visual version of the multiple choice tests for identification, terminology, and comprehension were taken from Dwyer (1985). In each case, the item stems were textual, while the options were visual (line drawings).

Total Comprehension Measure (80 items): This score was obtained by adding the scores for all four tests into a total test score. It was intended to provide a comprehensive assessment of the learner's overall understanding of the content presented.

Experimental Design

The study utilized a randomized, post test only, control group design. Each of the four visual treatments was tested against the two timing patterns in a 4 (visualization) x 2 (timing) mixed factorial design (Campbell & Stanley, 1966). Each of the eight treatments were subjected to five separate post-tests, or dependent measures. In Table 3, the post-tests are represented by O_1, O_2, O_3, O_4, O_5, which refer to Drawing, Identification, Terminology, Comprehension, and Total Comprehension tests, respectively.

Table 2. Mixed Factorial Design

Timing (T)	8-Second (T1)	Self-Paced (T2)
Visualization (V)	V_1T_1	V_1T_2
Still Images – Control (V_1)	V_2T_1	V_2T_2
Animation (V_2)	V_3T_1	V_3T_2
Graphic Reveal (V_3)	V_3T_1	V_3T_2
Animation and Graphic Reveal (V_4)	V_4T_1	V_4T_2

Table 3. Combinations of Treatments and Post-Tests

Tests (O) Treatments (V&T)	Drawing (O_1)	Ident. (O_2)	Termin. (O_3)	Comp. (O_4)	Total Comp (O_5)
V_1T_1	$V_1T_1O_1$	$V_1T_1O_2$	$V_1T_1O_3$	$V_1T_1O_4$	$V_1T_1O_5$
V_2T_1	$V_2T_1O_1$	$V_2T_1O_2$	$V_2T_1O_3$	$V_2T_1O_4$	$V_2T_1O_5$
V_3T_1	$V_3T_1O_1$	$V_3T_1O_2$	$V_3T_1O_3$	$V_3T_1O_4$	$V_3T_1O_5$
V_4T_1	$V_4T_1O_1$	$V_4T_1O_2$	$V_4T_1O_3$	$V_4T_1O_4$	$V_4T_1O_5$
V_1T_2	$V_1T_2O_1$	$V_1T_2O_2$	$V_1T_2O_3$	$V_1T_2O_4$	$V_1T_2O_5$
V_2T_2	$V_2T_2O_1$	$V_2T_2O_2$	$V_2T_2O_3$	$V_2T_2O_4$	$V_2T_2O_5$
V_3T_2	$V_3T_2O_1$	$V_3T_2O_2$	$V_3T_2O_3$	$V_3T_2O_4$	$V_3T_2O_5$
V_4T_2	$V_4T_2O_1$	$V_4T_2O_2$	$V_4T_2O_3$	$V_4T_2O_4$	$V_4T_2O_5$

Result and Discussion

Table 4. Mean Scores Achieved by Students on Each of the Criterion Tests

			Draw.	Ident.	Term.	Comp.	Total Comp.
Group	Treatment	N	Mean	Mean	Mean	Mean	Mean
V1	Static	50	17.50	17.72	14.06	13.16	62.44
V2	Progressive Reveal	50	15.78	17.40	13.20	12.76	59.14
V3	Animated	50	16.78	17.80	13.42	12.62	60.62
V3	Combined	50	16.12	16.96	12.90	12.26	58.24

ANOVAs conducted on the individual and total criterion measures indicated insignificant differences in achievement among the visual treatments. Significant differences in favor of the self-paced treatments were found to exist on the Drawing ($F=6.81$, $d_f=1/2$, $p.<.05$) and total Criterion Measures ($F=4.59$, $d_f=1/2$, $p.<.05$).

Table 5 presents the study times interacted with their respective treatments. Insignificant interactions were found to exist between the visual treatments and time on all criterion measure.

Table 5. Study Times (Means)

Group	Treatment	T_1 8-Second	T_2 Self-Paced
V_1	Static	152 sec.	173 sec.
V_2	Progressive Reveal	152 sec.	190 sec.
V_3	Animated	152 sec.	249 sec.
V_4	Combined	152 sec.	170 sec.

The results of this study indicated that the types of animation strategies employed provided insignificant differences in student achievement on the types of criterion measures measuring achievement of different types of educational objectives. The study also found that timed sequences were most efficient in terms of amount of time students spent interacting with the visualized treatments. These results implied that, at least for this group of learners, static visualization was sufficient to facilitate learning. This contradicted the current ideas and trends concerning the selection and use of animation in educational and learning environments.

A number of possible explanations may be suggested: (a) students were not properly oriented to the importance of the animation and thereby were not prepared to profit from the information being provided, (b) the experimental environment, itself, motivated all students, so that the control students interacting with the static visuals achieved as well as the students receiving the animated visualization, (c) the animation employed may not have been sufficiently intense so as to instigate the levels of information processing necessary to move the information from short term into long term memory. Finally, (d) the high cognitive abilities of the students involved may have pre-empted the need for dynamic visual support. Consequently, the students may not have worked conscientiously to integrate the animated information into higher levels of cognitive attainment (Rieber & Keni, 1991). In actuality their attention to the dynamic visualization may have impeded rather than facilitated the required levels of information processing.

It is also important to report that studies conducted by Lumsdaine, Sultzer, and Kopstein (1961) and May & Lumsdaine (1958) have indicated that animation, which is being used primarily to enhance the attention focusing or realism of a presentation, does not have a significant effect on learning. Anglin, Towers,and Levie (1996) have indicated that some progress is being made on visualization in facilitating knowledge acquisition, knowledge integration, and knowledge generation.

Considering the relationship between cost of producing different types of graphics and their relative effectiveness in promoting learning, this study demonstrated that, in some cases, still images can be as effective as more-costly animations. Hopefully, this will stimulate additional work into this important area of research.

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